

◆ CHAPTER 1. INTRODUCTION

PURPOSE

The purpose of the Strategic Plan is to guide restoration of the Bay-Delta ecosystem. It defines an ecosystem-based approach that is comprehensive, flexible, and iterative, designed to respond to changes in the complex, variable Bay-Delta system and changes in the understanding of how this system works. The Strategic Plan:

- establishes “adaptive management” as the primary tool for achieving ERP objectives and preparing to make future decisions for large-scale ecosystem restoration;
- describes the opportunities and constraints to be considered in developing a restoration program;
- presents broad goals and specific objectives for ecosystem restoration;
- presents a stepwise procedure for selecting restoration actions in which goals are linked through objectives to actions with appropriate consideration of the degree of confidence that objectives will be achieved;
- defines a coordinated approach for integrating the Ecosystem Restoration Program and the Multi-Species Conservation Strategy;
- provides the concept of a single blueprint for ecosystem restoration and species recovery in the Bay-Delta system.

The Strategic Plan does not:

- attempt to resolve issues of land use or conflicts with activities outside the ecosystem restoration program;

- attempt to resolve conflicts between species or between habitats, except for priorities implied by the statement of objectives; or
- recommend specific projects for implementation, although general classes of projects and a method for selecting projects are presented.

RELATIONSHIP OF THE ERP TO THE CALFED BAY-DELTA PROGRAM MISSION

The CALFED Bay-Delta Program was established to reduce conflicts in the Bay-Delta system by solving problems in ecosystem quality, water quality, water supply reliability, and levee system integrity. The mission of the CALFED Bay-Delta Program is to develop a long-term, comprehensive plan that will restore the ecological health and improve water management for beneficial uses of the Bay-Delta system. The Ecosystem Restoration Program

The Strategic Plan provides the conceptual framework and process that will guide the refinement, evaluation, prioritization, implementation, monitoring, and revision of ERP actions.

(ERP) is the principal Program component designed to restore the ecological health of the Bay-Delta ecosystem. The approach of the ERP is to restore or mimic ecological processes and to increase and improve aquatic and terrestrial habitats to support stable, self-sustaining populations of diverse and valuable species.

The ERP will also help fulfill the mission of improving water management for beneficial uses of the Bay-Delta system. Current protections for endangered and threatened fish species require that exports of Bay-Delta water be reduced or curtailed when they pose a risk to the species. By helping to recover currently endangered and threatened species and by maintaining populations of non-listed species, the ERP can help ease current diversion restrictions and preclude more stringent

export restrictions in the future, thereby improving the reliability of Bay-Delta water supplies.

The ERP represents one of the most ambitious and comprehensive ecosystem restoration projects ever undertaken in the United States. It encompasses a wide range of aquatic, riparian and upland habitats throughout the Bay-Delta ecosystem and near-shore ocean environment, and it addresses numerous aquatic and terrestrial species that rely upon the Bay-Delta ecosystem for part or all of their life cycle.

THE STRATEGIC PLAN FOR ECOSYSTEM RESTORATION

The ERP identifies over 600 programmatic actions that, after being refined and prioritized, will be implemented throughout the Bay-Delta ecosystem and near-shore ocean environment over the 30 or more year implementation period of the Program. The ERP is described in a two volume restoration plan, the Ecosystem Restoration Program Plan (ERPP), and the Strategic Plan for Ecosystem Restoration (Strategic Plan). Volume I of the ERPP describes the health and interrelationships of the elements of the Bay-Delta ecosystem and establishes the basis for restoration actions which are presented in Volume II of the ERPP. Volume II provides programmatic restoration prescriptions for ecological management zones and their respective units. The Strategic Plan provides the conceptual framework and process that will guide the refinement, evaluation, prioritization, implementation, monitoring, and revision of ERP actions.

The Strategic Plan signals a fundamental shift in the way the ecological resources of the Bay-Delta ecosystem will be managed, because it embodies an ecosystem-based management approach with its attendant emphasis upon adaptive management. Traditional management of ecological resources has usually focused upon the needs of individual species. Ecosystem-based management, however, is a more integrated, systems approach that attempts to recover and protect multiple species by restoring or mimicking the natural physical processes that help create and maintain diverse and healthy habitats.

THE STRATEGIC PLAN:

- describes an **ECOSYSTEM-BASED MANAGEMENT APPROACH** for restoring and managing the Bay-Delta ecosystem (Chapter 2);
- describes an **ADAPTIVE MANAGEMENT PROCESS** that is sufficiently flexible and iterative to respond to changing Bay-Delta conditions and to incorporate new information about ecosystem structure and function (Chapter 3 and Appendix C);
- describes the value and application of **CONCEPTUAL MODELS** in developing restoration actions and defining information needs, with examples of their development and use (Chapter 3 and Appendix B);
- presents **DECISION RULES** and criteria to help guide the selection and prioritization of restoration actions (Chapter 3);
- presents CALFED's broad **GOALS**, specific **OBJECTIVES AND RATIONALES** for ecosystem restoration (Chapter 4);
- presents **TWELVE CRITICAL ISSUES** that need to be addressed early in the restoration program (Chapter 5);
- describes **OPPORTUNITIES FOR RESTORATION** to address the twelve critical issues in the first seven years of implementation; (Chapter 5);
- describes Guiding Principles of the ERP and the approach for selecting actions for the **IMPLEMENTING THE ERP**, the first 7 years of Program implementation (Chapter 5); and
- describes **INSTITUTIONAL AND ADMINISTRATIVE CONSIDERATIONS** necessary to implement adaptive management, to ensure scientific credibility of the restoration program, and to engage the public in the restoration program (Chapter 6).

THE BAY-DELTA ECOSYSTEM

The Bay-Delta ecosystem is large, complex, diverse and variable. It contains California's two largest rivers, the Sacramento River (which drains an area of more than 25,000 square miles) and the San Joaquin River (draining more than 14,000 square miles). These two rivers converge in the Delta (Figure 1-1), which coupled with greater San Francisco Bay, forms the largest estuary on the West Coast. Tributaries that drain the Sierra Nevada Mountains, the Cascade Range, and the Coast Ranges provide freshwater flow to the Bay-Delta estuary, thus connecting the salty water of the Pacific Ocean with mountain forests and meadows into a vast ecosystem that encompasses most of the Central Valley.

California's semi-arid climate produces pronounced variations in both seasonal and inter-annual precipitation. For instance, the Bay-Delta watershed receives the vast majority of its annual precipitation between the months of October and April, with little precipitation between May and September. The amount of precipitation that falls in the Bay-Delta watershed can vary dramatically from year to year, as demonstrated during the last decade by the drought from 1987-1992 and the floods of 1995-1998. These seasonal and inter-annual variations in precipitation produce highly variable flows of freshwater through Delta tributaries and the estuary. Historically, during wet years, much of the Central Valley would flood to form a large inland sea of shallow water habitat, and during prolonged droughts, Bay-Delta tributaries were reduced to trickles confined within narrow low-flow channels.

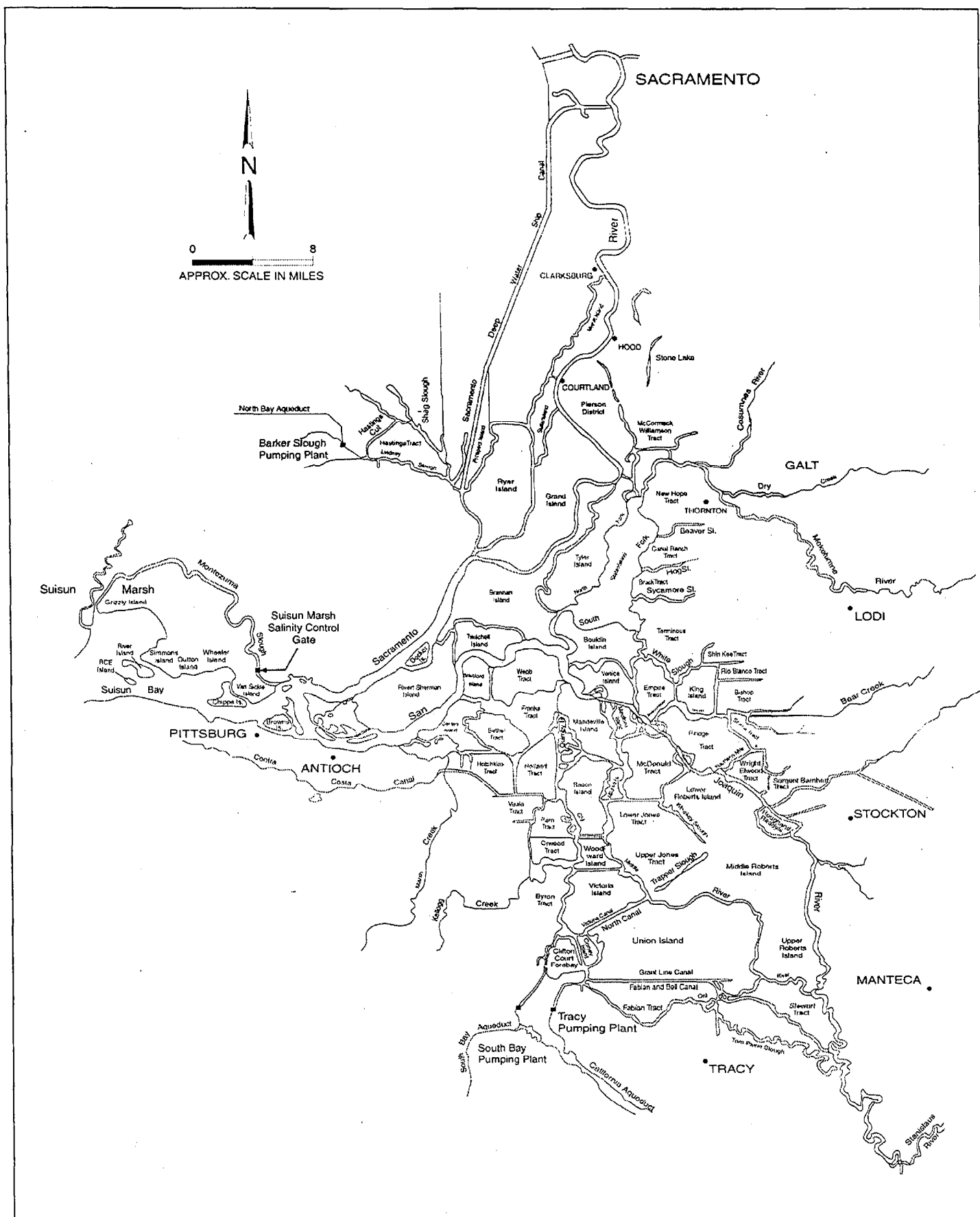
Regional differences in temperature and geology further cause variable flows of freshwater and sediment through Delta tributaries and the estuary. For instance, because of milder winter temperatures, most of the precipitation in the Coast Ranges falls as rain so that tributaries draining the eastern slope of the Coast Ranges produce peak flows during the rainy winter months, with reduced base flows from the late-spring through fall. In contrast, tributaries that drain the western flank of the Sierra Nevada Mountains usually carry peak flows later during the

late-spring and early-summer months because they are fed by melting snow stored in the mountains by colder winter temperatures, with late-summer and fall base flows greatly reduced following the snowmelt. Tributaries that drain volcanic formations around Mount Shasta and Mount Lassen also carry peak flows during late spring, but summer and fall base flows are relatively higher and colder since they are fed by cold-glacial melt water that flows from springs.

Such variation in the amount and timing of runoff—in conjunction with regional and local differences in soils, topography and microclimates—create an extraordinarily diverse ecosystem that contains numerous distinct habitats and communities and that supports numerous plant and animal species. For example, four distinct runs of chinook salmon that rely upon the Bay-Delta ecosystem demonstrate a fine-tuning of species to a fluctuating yet productive environment. Fall-run chinook spawn in low-elevation rivers, beginning their spawning migrations in fall months as soon as water temperatures are cool so that their young can emerge and leave the rivers before unfavorable flow and temperature conditions in the early summer. Spring-run chinook salmon beat the summer low flows and high temperatures by migrating far upstream in the spring and holding in deep, cold pools through summer, waiting to spawn in the fall. Tributaries draining volcanic formations (such as the little Sacramento, McCloud and Pit rivers) provided cool water temperatures during summer months, allowing late-fall-run and winter-run chinook salmon to spawn late in the season. The ERP reflects the diversity within the Bay-Delta ecosystem by delineating 14 ecological management zones, each of which is subdivided further into smaller ecological management units.

THE NEED FOR RESTORATION

Numerous plant and animal species that rely upon the Bay-Delta ecosystem are listed as endangered or threatened, or experiencing declines in population abundance or geographic distribution. Some species that depended on the Delta, such as the thicktail chub, are now extinct. Such species declines indicate a much broader problem with



deteriorating ecological health in the Bay-Delta ecosystem, as indicated by:

- a reduction in the quantity, quality, and diversity of aquatic and terrestrial habitat available to support a variety of fish, plants, birds, reptiles, amphibians, and other species;
- the alteration of the amount and pattern of water and sediment movement in Delta tributaries and through the Delta;
- the disconnection of rivers from their floodplains by levees and from their headwaters by dams;
- the alteration of the movement patterns of fish and other organisms by dams, channel modifications, changes in hydrology, and water diversions;
- the introduction of numerous non-native species, some with tremendous capacity for damage to the extant ecosystem, and the establishment of conditions that favor these species; and
- the degradation of water quality from pesticides, herbicides, industrial and municipal discharges, non-point-source discharges, and concentration of natural toxins through leaching from farms.

Healthy ecosystems provide more than habitat for plants and wildlife; they also meet the needs of human communities. Some of the obvious human benefits include drinking water supply, recreational opportunities, and amenity values. But healthy ecosystems also provide more subtle, but no less important, benefits to human communities. For instance, vegetation helps to improve air quality and sequester carbon, rivers help transport and

dilute our wastes, biotic organisms can help improve water quality and pollinate crops and vegetation, etc. In this manner, ecological processes provide valuable goods and services. Similarly, the amenity values associated with high-

quality environments can help attract businesses to locate in the state, thereby stimulating local, regional, and state economies (Power 1996).

Historically, human activities have focused on the extractive value of natural resources and ecological processes without sufficient consideration of the concomitant loss of other social and economic benefits when ecological systems are altered (Healey 1998). However, growing public recognition of the social, economic, and ecological costs of environmental degradation, coupled with a growth in

environmental values, has stimulated interest not only in preserving remnant ecosystems, but also in restoring already degraded ecosystems

What is Ecosystem Restoration?

Ecosystem restoration does not entail recreating any particular historical configuration of the Bay-Delta environment; rather, it means re-establishing a balance in ecosystem structure and function to meet the needs of plant, animal, and human communities while maintaining or stimulating the region's diverse and vibrant economy. The broad goal of ecosystem restoration, therefore, is to find patterns of human use and interaction with the natural environment that provide greater overall long-term benefits to society as a whole.

WHAT IS ECOSYSTEM RESTORATION?

Ecosystem restoration projects throughout the world—such as projects in the Chesapeake Bay and Florida Everglades—have helped to publicize and popularize the concept of ecosystem restoration. However, a significant amount of confusion and contention still surround the concept of ecosystem restoration (Richardson and Healey 1996). Much of the confusion and contention stems from the perceived goal of ecosystem restoration; that is, the term itself seems to imply that the ecosystem will be restored to its pristine, pre-disturbance condition or some structural and functional configuration defined by a particular historic baseline. Thus, some stakeholders worry that ecosystem restoration will require the cessation of particular human activities that disturb an ecosystem, with subsequent economic dislocations. Although ecosystem restoration does require

change and adjustment, there is no benefit to ecosystem restoration if it destroys the fabric of the society it is intended to serve.

Ecosystem restoration does not entail recreating any particular historical configuration of the Bay-Delta environment; rather, it means re-establishing a balance in ecosystem structure and function to meet the needs of plant, animal, and human communities while maintaining or stimulating the region's diverse and vibrant economy. The broad goal of ecosystem restoration, therefore, is to find patterns of human use and interaction with the natural environment that provide greater overall long-term benefits to society as a whole. **FOR THE ERP, WE USE THE TERM "RESTORATION" TO ENCOMPASS THE CONCEPTS OF REHABILITATION, RESTORATION, PROTECTION AND CONSERVATION.**

ACKNOWLEDGING EXISTING CONSTRAINTS TO ECOSYSTEM RESTORATION

Several human activities in the Bay-Delta watershed have irreversibly altered important ecological processes (see Appendix A). Nevertheless, these activities provide important public benefits and ecosystem restoration must occur within the parameters established by these human activities. For example, the large reservoirs and diversion facilities that comprise the Central Valley Project and State Water Project have radically altered the hydrology of the Bay-Delta ecosystem. Reservoir storage in the Sacramento River Basin captures approximately 80% of annual average runoff, while storage capacity in the San Joaquin River system detains nearly 135% of annual average runoff (San Francisco Estuary Project 1992, Bay Institute 1998). Such profound hydrologic changes underscore the numerous ecological processes that dams alter: they reduce the frequency and magnitude of flood flows that drive channel migration, scour encroaching vegetation, and cleanse spawning gravels; they trap sediment and woody debris necessary to maintain important instream habitat; they reduce the natural flow variability to which native species and communities have adapted; and they block access to historical spawning habitat for anadromous fish.

Although dam removal may be possible in a limited number of cases, in most cases ecosystem restoration must occur within the parameters established by existing reservoirs. The multiple public benefits provided by most existing dams—water supply, flood storage, hydropower, recreation—simply preclude their removal.

Ecosystem restoration attempts to maintain the public benefits that existing dams provide while enhancing other public benefits associated with ecosystem restoration by better managing human activities. For instance, habitats, communities and species in the Bay-Delta ecosystem have evolved in response to the fluctuating flow conditions produced by variable precipitation patterns. Dams have reduced the natural variability of flows in Bay-Delta tributaries to the detriment of the ecosystem, but it is possible to re-operate reservoir releases so that they restore or mimic natural flow variability. In this manner, existing reservoirs can still provide—though they may diminish—water supply, flood storage, hydropower, and recreational benefits, but they can also enhance the public benefits of a healthier ecosystem by approximating a more natural flow regime.

ACKNOWLEDGING FUTURE CONSTRAINTS TO ECOSYSTEM RESTORATION

The existing constraints to ecosystem restoration in the Bay-Delta are a function of human uses of Bay-Delta resources. The California Department of Finance projects that the state's population will grow by approximately 15 million people (or nearly 48%) over the life of the Program, thereby increasing demands upon Bay-Delta resources and introducing additional constraints to restoration (see Appendix A). Ecosystem restoration must balance the need to provide resources for future consumptive use with the need to provide high-quality environments that fulfill the needs of plant, animal, and human communities.

THE SCOPE AND FOCUS OF THE ERP

The CALFED Bay-Delta Program was created to

develop solutions for water and environmental management problems of the Bay-Delta system. The Program's legally defined **PROBLEM SCOPE** is the Sacramento-San Joaquin Delta and Suisun Bay and Marsh, the hub of the state's water system as well as an important estuary that many imperiled species are critically dependent on. The geographic scope for developing solutions to environmental problems is the entire watershed and near-shore ocean environment of the Bay-Delta system. While the ERP identifies programmatic actions to be implemented throughout the watershed and near-shore ocean, the ERP delineates a more focused area where the majority of actions will be implemented—the **STUDY AREA**. The Study Area includes the legally defined Delta, Suisun Bay and Marsh, North San Francisco Bay, the Sacramento and San Joaquin Rivers and their tributaries downstream of major dams (Figure 1-2). Within the Study Area, 14 Ecological Management Zones and their associated Ecological Management Units (52 units total) are delineated. Volume II of the ERPP describes the health of these management areas and presents specific management prescriptions.

This focused Study Area reflects existing constraints to ecosystem restoration. For example, large dams represent irreducible discontinuities in rivers by altering flows, trapping sediment, and impeding fish passage, such that restoration efforts in the upper watersheds are unlikely to contribute significantly to key ERP goals such as restoring ecological processes and recovering endangered and threatened species. Restoration and management actions implemented in the upper watersheds can yield other Program benefits, such as water quality and water supply improvements and reductions in reservoir sedimentation. Accordingly, other Program components, such as the Watershed Management Program and the Water Quality Program, address the upper watersheds. Similarly, there are relatively fewer management actions relevant to the CALFED mission available for central and southern San Francisco Bay.

Numerous plant and animal species rely upon the Bay-Delta ecosystem for part or all of their life cycle, and the ERP aims to maintain current population abundances of these species, at a

minimum. However, a majority of programmatic actions contained in the ERP focus on improving ecological processes and habitats upon which endangered and threatened species or species proposed for listing depend since there is a more immediate need to stabilize their populations and since their recovery will help reduce conflicts in the Bay-Delta system.

RELATION OF THE STRATEGIC PLAN TO THE MULTI-SPECIES CONSERVATION STRATEGY

CALFED has developed a Multi-Species Conservation Strategy to serve as the platform for compliance with the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA) (Multi-Species Conservation Strategy 1999). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recovery of the species, (2) contribute to their recovery, or (3) maintain existing populations. The "recover species" depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds. These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper

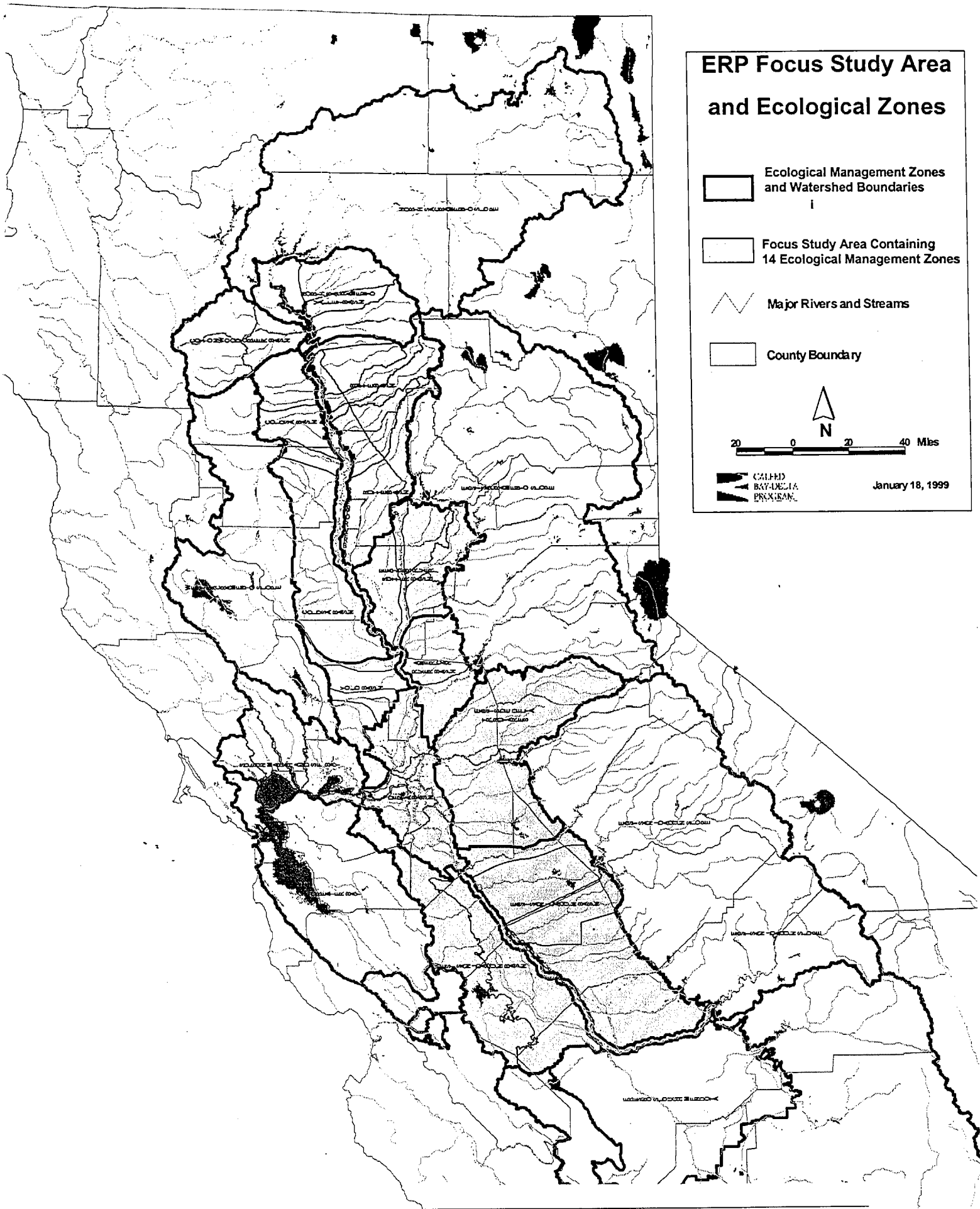


Figure 1-2: Ecosystem Restoration Program Study Area and Ecological Management Zones

watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Watershed Program addresses the coordination of planning and restoration actions in the upper watershed .

The MSCS and the ERP are distinct parts of CALFED, but they are neither severable nor redundant. The ERP is the means by which CALFED will restore the Bay-Delta ecosystem and is the CALFED element most relevant and important for FESA, CESA, and NCCPA compliance. The MSCS conservation measures do not comprise all actions that will be credited toward, or required for, compliance with FESA, CESA, and NCCPA. The MSCS is not a separate or supplemental restoration program and does not supplant the ERP.

Rather, the MSCS:

- assesses the aggregate effects of CALFED, including implementation of the entire ERP;
- identifies species goals consistent with the ERP that reflect regulatory standards;
- refines and emphasizes certain ERP actions that are of special importance to the MSCS evaluated species; and
- identifies avoidance, minimization, and compensation measures for evaluated species.

The MSCS's species goals and conservation measures are consistent with and are incorporated in the ERP. ERP actions that are not emphasized or refined in the MSCS may nonetheless be important for FESA, CESA and NCCPA compliance. USFWS, NMFS and DFG will consider all proposed CALFED actions that would benefit or harm the MSCS's NCCP communities and evaluated species, including all ERP actions, for purposes of determining whether CALFED complies with FESA, CESA, and NCCPA.

◆ CHAPTER 2.

ECOSYSTEM-BASED MANAGEMENT

THE ADVANTAGES OF ECOSYSTEM-BASED MANAGEMENT

Natural resource management is often guided by the need to recover and protect populations of endangered and threatened species. Efforts to combat population declines of endangered and threatened species often focus on specific factors in a species' environment believed to affect birth or death rates. While this species-based approach has often prevented the extinction of a species, it has also resulted in piecemeal attempts that usually fail to recover and stabilize populations of threatened and endangered species. Additionally, this species-based approach fails to address the needs of unlisted species experiencing population declines that might necessitate their future listing.

Ecosystems are more than just a collection of species; they are complex, living systems influenced by innumerable climatic, physical, chemical, and biological factors, both within and outside of the ecosystem. A new paradigm in natural resource

management has emerged that acknowledges this complex interplay of forces that shape and animate ecosystems. Ecosystem-based management is an integrated-systems approach that attempts to protect and recover multiple species by restoring or mimicking the natural physical processes that create and maintain diverse and healthy habitats.

By incorporating an ecosystem-based approach, the ERP and the Strategic Plan signal

a fundamental shift in the way the ecological resources of the Bay-Delta system will be managed.

By adopting an ecosystem-based approach, CALFED is not relinquishing its responsibility to recover endangered and threatened species, nor is it abandoning all species-based management efforts. Ecosystem-based management encompasses species management by enhancing and sustaining the fundamental ecological structures and processes that contribute to the well-being of a species. The ERP aims to recover threatened and endangered species not only by restoring habitats, but also by restoring the ecological processes that help create and sustain those habitats.

CONTRASTING ECOSYSTEM- BASED AND SPECIES-BASED MANAGEMENT

The difference between process-based restoration and conventional species-based management can be illustrated by the contrast between using hatcheries and ecosystem-based approaches to

restore salmon.

Hatcheries were initially constructed to compensate for habitat lost behind dams, but they are now used to compensate for a broad range of impacts on salmon production, including habitat degradation. This

conventional, engineering-oriented, species-based approach yields an increase in fish populations, at least in the short term; however, hatcheries are vulnerable to disease and impose a variety of selection pressures that

Advantages of an Ecosystem-Based Approach over the Traditional Species-Based Approach

- Restoration of physical processes reproduces subtle elements of ecosystem structure and function in addition to the more obvious elements, thereby possibly enhancing the quality of restored habitat.
- Restoration of physical processes can benefit not only threatened and endangered species, but also unlisted species, thereby reducing the likelihood of future listings.
- Restoration of physical processes reduces the need for ongoing human intervention to sustain remnant or restored habitats.
- Restoration of physical processes may produce a more resilient ecosystem capable of withstanding future disturbances.

may make the fish less successful in the wild. Hatchery-produced fish compete with, and interbreed with wild fish, thereby affecting the gene pool and possibly reducing the fitness and overall vigor of local populations.

By contrast, a process-based ecosystem management approach seeks to restore the dynamic processes of flow, sediment transport, channel erosion and deposition, and ecological succession that create and maintain the natural channel and bank conditions favorable to salmon. If the processes that create the habitat for salmon can be restored, ecosystem restoration can be truly sustainable and can result in a system that benefits a range of other species as well, thereby avoiding future need for further listings of endangered species.

ELEMENTS OF ECOSYSTEM-BASED MANAGEMENT

In its monograph on the scientific basis of ecosystem management, the Ecological Society of America (1995) identified eight elements of ecosystem-based management that illustrate the character of this emerging paradigm:

1. **LONG-TERM SUSTAINABILITY IS A FUNDAMENTAL VALUE.** This element highlights the importance of intergenerational equity, suggesting that resources should be managed today to ensure that the needs of future generations will not be compromised (World Commission on Environment and Development 1987). In ecological terms, this is coming to be defined as passing on to future generations a set of natural capital resources equivalent to that which the present generation has available (Costanza and Daly 1992). The ERP addresses this element in by emphasizing the recovery of native species, by preserving biodiversity, and by emphasizing the restoration of ecological processes that allow ecosystems to be more self-sustaining.
2. **DECISIONS MUST BE BASED ON CLEARLY DEFINED GOALS AND OBJECTIVES.** This element highlights the need to be clear about what we want to achieve through management. Goals and objectives are to be
3. **DECISIONS MUST BE BASED ON SOUND ECOLOGICAL MODELS AND UNDERSTANDING.** This element highlights the importance of rational, science-based models to decision making in ecosystem-based management. However, because humans are integral to the ecosystem to be managed, it also highlights the importance of models that integrate social, economic, and environmental components of the larger system. Conceptual models as heuristics and as a foundation for modeling expected outcomes in adaptive management are part of the Strategic Plan.
4. **COMPLEXITY AND CONNECTEDNESS ARE FUNDAMENTAL CHARACTERISTICS OF HEALTHY ECOSYSTEMS.** Evidence from management failures of the past suggests that there is considerable risk in attempting to manage individual resources independently of one another. By focusing attention on connectedness, ecosystem management reduces the risk of such failures. Restoration of Delta and estuarine ecosystems inevitably involves a concern with connectedness because of the importance of fluvial and tidal dynamics to their functioning. Recognition of the importance of interconnected habitats is also paramount when anadromous salmonids are one subject for restoration. The nested hierarchy of ecosystem management units in the ERP focus area is a further acknowledgment of the interconnectedness among elements of structure and function in the ERP focus area.

5. **ECOSYSTEMS ARE DYNAMIC.** Ecosystems are complex, self-organizing systems. With complexity comes uncertainty and imprecision in prediction. Ecosystem-based management cannot eliminate surprises or uncertainty. Rather, it acknowledges that unlikely and even unimagined events may happen. The

management process must be designed to cope with such events. The Strategic Plan describes an adaptive management process that helps to account for the uncertainty inherent in restoring and managing an ecosystem. The program also recognizes the importance of dynamic processes in its concern over effects of the seasonal hydrograph on particular species and in its plan to recreate meander corridors along river courses. Other

dynamic elements may have to be built into the restoration program over time, however, and adaptive experimentation can help to define the necessary degree of dynamic change to maintain ecosystem function.

6. **CONTEXT AND SCALE ARE IMPORTANT.** Each aspect of ecosystem structure and function has its own time and space scale. Spatial and temporal domains of management planning and implementation need to be congruent with those of critical ecological processes in the system to be managed. Management activities tend to be tied to social and economic schedules, not ecological schedules. Staged implementation, monitoring, and assessment schedules and adaptive experimentation all provide tools for strengthening the spatial and temporal patterning of restoration.
7. **HUMANS ARE INTEGRAL COMPONENTS OF ALL ECOSYSTEMS.** Humans are the single greatest modifier of ecosystem structure and

function. Humans will also suffer the most serious consequences of changes that make ecosystems less able to sustain human life. Therefore, management of human activities must be an integral component of plans to manage ecosystems. This element may seem rather obvious but serves to emphasize the

importance of linking the ERP with activities related to water quality, water supply reliability, and levee integrity. This element also reminds us that ecosystem management is a human problem, not an ecological one.

8. **ECOSYSTEM MANAGEMENT**

MUST BE ADAPTABLE AND ACCOUNTABLE. Our understanding of ecosystems is incomplete and

subject to change, so management planning and programs must be sufficiently flexible to respond to new information. Adaptive management provides this flexibility, and it employs the problem-solving power of the scientific method to maximize the information value of restoration actions so that we can improve our knowledge of the ecosystem as we restore it, thus improving the process of management over time.

ADDRESSING THE UNCERTAINTY INHERENT IN NATURAL SYSTEMS THROUGH ADAPTIVE MANAGEMENT

Through decades of scientific research, we have come to understand much about the Bay-Delta ecosystem and the species that depend on it; however, we do not understand all of the ecological processes and interactions that animate the ecosystem. Additional research can greatly improve our understanding, but it will never erase

Elements of Ecosystem-Based Management

1. Long-term sustainability is a fundamental value.
2. Decisions must be based on clearly defined goals and objectives.
3. Decisions must be based on sound ecological models and understanding.
4. Complexity and connectedness are fundamental characteristics of healthy ecosystems.
5. Ecosystems are dynamic.
6. Context and scale are important.
7. Humans are integral components of all ecosystems.
8. Ecosystem management must be adaptable and accountable.